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TIME SERIES FORECASTING AS A TOOL OF OPERATIVE MANAGEMENT

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Present quickly varying business environment requires changes in traditional logistic management of companies of chemical and food industry operating on B2C markets. Usage of recent logistic technologies however is made impossible due to the position of Czech companies on the markets mentioned. This article presents the problems which these companies solve on the operative level, and points out possibilities of time series analysis utilization as a tool of demand planning. Possible application of this tool in operative management and its incidences are described on a chosen company of food industry.

Introduction

Global markets on which companies operate nowadays are mainly characterized by quick and hardly foreseeable changes, by supply overpressure (overhang) above demand, by rapid development of information and communication technology and

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by well-informed and demanding customers. As a consequence, there is strong orientation on customer and development of systems of differentiated CRM based on customer value [1]. This is the reason why maximum satisfaction of even individual customer requirements mainly in the field of individually provided logistic services are main aims for companies. Time plays important, if not key role in it. This means for companies that they must be able of quick and adequate reaction on customer's requirements.

This can be assured only on condition of high flexibility and effectiveness not only of business processes but even of the whole supply chains, of which the company is a link. It results in the development of Supply chain management and many logistic technologies. Ability of all supply chain links to share needed information and knowledge is the basic condition for implementation of these technologies. Primarily, it is sharing of joint demand forecast and its unified utilization in planning process of all links of chain — demand planning. It requires not only technical and software securing of these information transfers, which are often shared on-line, but also confidence between individual links and their willingness to cooperate and to share information. Under these conditions methods as JIT (Just in Time), QR (Quick Response), ECR (Efficient Consumer Response), CRP (Continuous Replenishment Planning), RMR (Retail Management Replenishment), VMI (Vendor Managed Inventory), CFaR (Collaborative Forecasting and Replenishment), CPFR (Collaborative, Planning, Forecasting and Replenishment) can be successfully implemented. Many of companies in the Czech Republic are a part of supply chains, in which there is for many reasons no willingness to cooperate in the field of information sharing about demands and sales [2]. Those are namely manufacturing companies, which supply their products into foreign retail chains, where also companies of chemical and food industry belong. Sales forecast derived on the basis of analysis of sales time series is one of the tools which can help in solution of these problems.

Time Series Forecasting and Application in Operative Management

Time series forecasting is based on analysis of data recorded over a period of time, discovering of the pattern in the historical data, and extrapolate that pattern into the future. The business series follow various patterns. Study of the types of data patterns is an important step in selecting an acceptable time series model. Operative management is working with sales data rarely older than several months. That collection of data forms short-term time series with horizontal pattern. A horizontal pattern presents data values fluctuating around a constant mean. A random fluctuation around constant value is typical for stable processes with stochastic defects, products with stable sales or most of the short-term time series of sales. Thus these time series often miss secular trend, seasonal and cyclical

variation. There are two basic techniques used in time series forecasting with horizontal data pattern in the literature (see, e.g., Refs [3-6]):

- Simple Moving Average,
- Single Exponential Smoothing.

The moving-average method can be useful in removing the random fluctuations for forecasting. Although moving averages are centered, it is more convenient to use them to predict the following period of time series. Then the formula for a simple moving average is

$$F_t = \frac{A_{t-1} + A_{t-2} + \ldots + A_{t-n}}{n} \tag{1}$$

where F_t is forecast for the coming period, n is number of period to be averaged, A_{t-i} is actual sales i-periods ago.

Exponential smoothing is the most used of all forecasting techniques. The formula for single exponential smoothing results from modified Eq. (1) and is mathematically represented as follows

$$F_t = (1 - \alpha)F_{t-1} + \alpha A_{t-1} \tag{2}$$

where α is smoothing constant which determines the level of smoothing and the speed of reactions to differences between forecasts and actual occurrences.

The value of sales forecast is the most important information in the operative management. It is especially used in production planning and inventory control. The forecast accuracy can facilitate operative decision making. All forecasts contain some error because of the interaction of many indefinable factors in the model. Forecast error is definition for differences between the forecast value and what actually occurred. The common terms used to describe the degree of error are mean absolute deviation (*MAD*) and mean absolute percentage error (*MAPE*) defined as follows

$$MAD = \frac{1}{n}\sum_{t=1}^{n} |A_t - F_t| \tag{3}$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} \left|\frac{A_t - F_t}{A_t}\right| 100 \tag{4}$$

where t is period number, A is actual sales for the period, F is forecast sales for the period, and n is total number of periods. When the errors that occur in the forecast are normally distributed (the usual case), the mean absolute deviation relates to the standard deviation as [3]

$$\sigma = \sqrt{\frac{\pi}{2} MAD} \tag{5}$$

where σ is standard deviation. Knowledge of standard deviation determines utilization of historical data to quantify the volume of the safety stock [4].

Characteristics of Companies

Manufacturing companies of food industry equally as the majority of companies of chemical industry producing consumer goods get significant part of produce to final customers through retailers. The present era is characterised by growing bargaining strength of retail chains mainly as consequence of the fact that manufacturers' offer significantly exceeds demands of end users. If manufacturers want to hold a market, they must be able to realize in a very short time period very quickly changing requirements of retailers and to agree to the disadvantageous terms of supplier-customer relations. Retailers are not willing to share information about consumer demand or behaviour. Though, the customer service lead time has to be a far smaller interval than the lead time required by the company to produce or distribute the product. It reflects on increasing requirements of operative management of manufacturing, purchase, but also on other logistic activities along the whole supply chain. Thus, demand planning is one of the few instruments how to control processes in this case. Possibilities of forecasting exploitation will be demonstrated on a specific company, which cannot be disclosed due to the data sensitivity [7].

The company chosen for analysis is a dairy with long tradition of producing dairy products. It occupies strong position on Czech market above all in the segment of butter-type spreads, cream spreads, cream yogurts and cottage cheeses. Considering existence of a great number of tastes, range of products of the company contains about thirty various kinds of products. Portfolio of products differs also by the size of consumer package (several consumption packages, gastro production). The company is selling these products also under a few private trade marks of Czech and foreign retail chains in comparable quality, but in different consumer packages. The company gets more than two thirds of produce to final customers through retailers. The company's position in the marketplace analysis revealed all problems stated in the previous paragraph. The company position is also complicated by short-term usable life of the products (several days or weeks). Although key raw material for all products manufacturing is cream which is purchased from farmers with one week lead and average production cycle is three days, the customer service lead time is usually one day. In addition, customers accept only delivery of products with full usable life or only with its

partial expiration. Key customers make use of fixed-time period model ordering and withdraw products several times on the basis of the order from previous day.

The fluency of material flows in the company is ensured by managers with long-time experiences. However, there is a little correspondence between operational plan and operative management. Even managers find some steps of operative management uneconomical. For this reason, operative planning and control was analyzed in the company. Following processes which influence processes effectiveness mostly were identified by the analysis:

- weekly demand planning,
- weekly purchase of cream,
- weekly production scheduling,
- safety stock of final production assessment.

Weekly forward sales are estimated in the company on the basis of executed sales over the last period. This estimation has low accuracy but it presents basic information for purchase of cream which has to be ordered a week before consumption. The production is daily controlled by executed sales currently. Production scheduling is complicated because of unpredicted fluctuations in sales and stint of purchased cream. Safety stock of final production is not quantified but average reserve/stock in store of finished goods corresponds to roughly average week sale. Thus it is possible to assume, that safety stocks make about one half of average week sales.

It is obvious that this kind of management based on innocence of accuracy and reliability exactly ascertained forecast, requires big amount of operative interferences. This management is in addition related to skills and experiences of concrete people, with their departure this non systemic management is not in the long term maintainable. Time series analysis could be one of the few instruments how to control processes at the operative level.

Results of Time Series Analysis and Discussion

Time series analysis was focused on the possibility to predict weekly sales providing primary information for operative control. Sales of model product whose time series were not misrepresented by promotion were used to research. Time series of sales executed by three characteristic retailers (retailer A, B and C) were analysed during forty weeks in 2008. Retailer A and B represents foreign retailers (retailer A is the key customer of company), and retailer C is a representative of Czech retailers. Time series were smoothed by moving-average method and single exponential smoothing. Forecast error was described by MAPE. In view of the production cycle and purchase of cream it was necessary to modify both of forecasting equations as follows

$$F_t = \frac{A_{t-2} + A_{t-3} + \ldots + A_{t-n-1}}{n} \tag{6}$$

$$F_t = (1 - \alpha)F_{t-1} + \alpha A_{t-2} \tag{7}$$

that returns forecasts a week before models (1) and (2). Those sales forecasts are really usable in operative management in this case.

It is important to select the best period *n* for the moving average (6). The greater random fluctuations are smoothed by the longer moving-average period. But there is the need to have a large amount of historical data and there is a problem that medium-term changes in possible trend can be lost. Number of periods was chosen from 2 to 9 and the influence on forecast accuracy was monitored.

In the single exponential smoothing (7), alpha is given a value between 0 and 1. The low value of alpha keeps information from data many periods ago, whereas the higher value prefers the actual demand to historical data. Adjusting the value of the constant can also help with reaction to changes in possible trend. Therefore, the smoothing constant was optimized by minimisation of *MAPE* because the choice of alpha influences the forecast accuracy extremely. The values of *MAPE* depending on choice of smoothing constant are shown in Fig. 1.

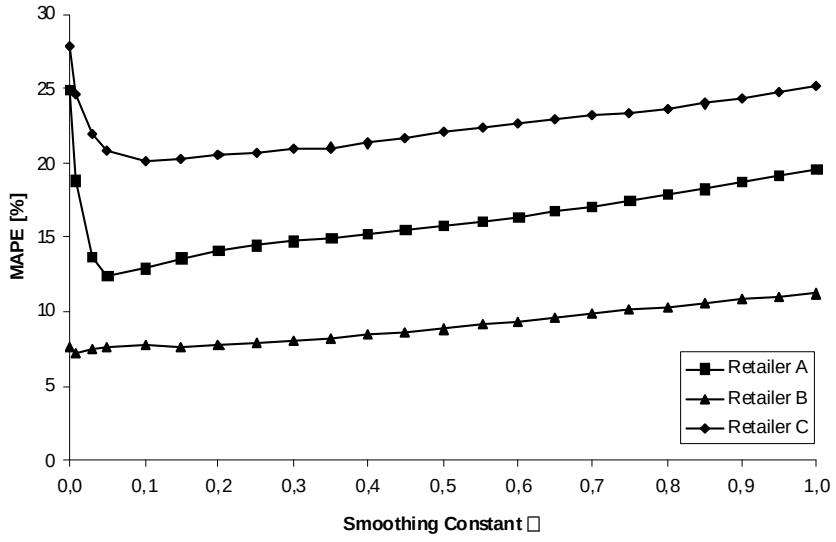

Fig. 1 Smoothing Constant-MAPE Diagram

Comparison of the MAPE values obtained by application of forecast techniques and by predicting in the company is shown in Table I. The forecast error was the lowest in the single exponential smoothing with optimal smoothing constant (α_{OPT}). Time series analysis based on this technique is shown in Fig. 2.

Utilization of exponential smoothing would reduce forecast error by more than 7 % in sales of the key customer. Low values of optimal smoothing constants

as well as descending forecast error with simultaneous ascending number of period

Table I Forecast Techniques Comparison by Forecast Accuracy (MAPE)

		Retailer A	Retailer B	Retailer C
MAPE of company prediction, %		19.5	11.2	25.2
α_{OPT}		0.062	0.007	0.090
MAPE of single exponential smoothing, %		12.1	7.2	20.1
MAPE of single moving average, %	$n = 2$	16.5	9.6	23.9
	$n = 3$	15.4	8.7	22.1
	$n = 4$	15.1	7.6	21.8
	$n = 5$	14.4	7.2	20.4
	$n = 6$	14.3	7.6	21.0
	$n = 7$	14.3	7.5	21.0
	$n = 8$	13.7	7.3	20.6
	$n = 9$	13.7	7.5	20.5

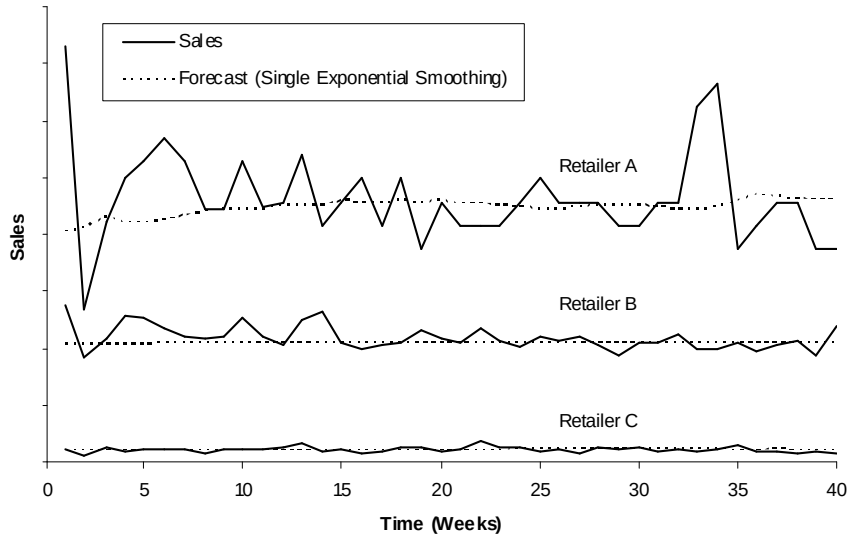

Fig. 2 Utilization of Single Exponential Smoothing to Time Series Analysis

in moving-average methods point out that data values really fluctuate around a constant indeed. This information can be decisive for capacity planning and fixed production scheduling without necessity of bigger operations intervention. Constant mean of weekly sales determines weekly production and weekly purchase of cream. Random fluctuations of sales values could be covered by safety

stock of final production.

High variance of sales data of key customer (retailer A) is decisive for safety stocks quantity because sales variance of the others is insignificant in absolute point of view (see Fig. 2). Safety stocks value based on time series analysis amounts 50 % of average weekly sales. Carrying of high inventory would not reduce costs. But the company can profit through integration of processes via unified joint forecasts within the whole company. High level of safety stocks of final product would have other negative effects. In regard of short-term usable life of some products, part of the produce would be sometimes damaged or cut under. In the case of repeated exhaustions of safety stocks it could happen that production capacity could be not sufficient for their replenishment, and in some cases, significant part of week capacity would have to be hold for the case of excessive exhaustion of stocks. The degree of impact of these implications, however, can be find out only after full analysis of time series of all sales realized by the company. Such analysis has not been carried out yet, because the company does not dispose with database of historical sales enabling bulk data processing for all items of selling assortment.

At present, the company deals with implementation of suitable information technologies. They would enable forecasting based on time series analysis and its exploitation in another company functions and namely particularly in planning and management of production/manufacturing. Integration of company functions, roofed-over by in-house information system, represents one of the fundamental conditions not only of effective exploitation of forecasting in operations management, but also of the whole intellectual conception of demand planning [8].

Conclusion

Orientation of companies on customers requires changes in management not only of individual companies, but of the whole supplier — customer chains. Situation on markets with fast turning consumer goods though inhibits logistic technologies' implementation. This is the reason of very frequent undesirable operative interference into production plans or of disproportionate increase of finished products´ reserves. Operative management within the company can be streamlined through integration of business process via sharing of joint forecast in all business functions.

It has been shown on the above mentioned company, that basic techniques of time series analysis can be successfully applied for needs of operative management. Prediction models can be surely modified for particular needs of each company, whereas gained forecasts can result in significant specification of sale judgment. In the case of stated example the forecast at the biggest customer was improved from 19.5 % on 12.1 %. Achieved error of forecast cannot be

removed through analysis of this type time series, because it is caused by unpredictable behaviour of customers. By analysing time series it has been found out that values of former sales fluctuate around a constant average value, which is not changed significantly from the long-term point of view. It allows implementation of integrated control, because of which significant decrease of interferences in operations management should take place.

In spite of the fact, that interconnection of demand forecasting process with all planning activities within the company can become competitive advantage, this interconnection evokes frustration of majority workers. One from many other reasons is the fact that demand forecast is based on probability and from its principle it can never be taken as fully reliable. Potentiality of forecast exploitation, however, does not depend on the level of its reliability only. Each assessed forecast is an effective tool for decision making, because each decision comes out from certain judgment of the future. Additional reasons why quantitative methods generally are not applied in practice are apprehensions from necessary changes in management [9]. These changes are, in addition, often connected with investments mainly into information technology. But if companies want to keep their position within supply chain, they cannot avoid changes in management.

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